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Biology and rearing performance of *Actias selene* Hübner (Lepidoptera: Saturniidae), a wild silk moth in Nagaland, India

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Abstract *Actias selene* Hübner, an indigenous vanya silk moth is trivoltine in nature and undergoes 97.6±4.37 days winter pupal hibernation in the climatic conditions of Nagaland, India. The worm is polyphagous in nature and feeds on six host plants, among which rearing was conducted on two host plants, namely, *Alnus nepalensis* (Alder) and *Rhus javanica* (Tangmo) in three rearing seasons (March-May, July-August and October-December) for two consecutive years. Each larval instar of *A. selene* worms has a distinct body colour and tubercular arrangement. On the basis of host plant preference they also exhibit seasonal variation in production parameters (Fecundity, Hatching percentage, ERR percentage and Cocoon/Dfls ratio), life cycle parameters (Duration) and cocoon parameters (Length, Breadth, Weight, Shell weight and Shell ratio). The cocoon has, apparently, no sericultural value, but reelable cocoons with a filament length (mts), filament denier (d) and raw silk recovery (%) of 78.1±4.41-198.82±, 5.09-11.57 and 41.57-58.86% and 86.84±5.40-163.22±8.56, 6.67-8.85 and 35.63-43.32% on *Rhus javanica* and *Alnus nepalensis*, respectively, in different rearing seasons are described for the first time.

Key words *Actias*, *Rhus*, *Alnus*, Nagaland, Indian moon moths.

Introduction

Actias selene Hübner (Indian moon moth), an indigenous vanya silk moth is geographically distributed in tropical moist deciduous forest (Lefroy, 1909). Earlier, moon moths were recorded from Mussourie and Sikkim in India (Cotes, 1891–1893; Arora and Gupta, 1979); Afghanistan to Borneo (Jordan, 1911); Hongkong (Potter, 1941); China, Japan and Ceylon (Essig, 1941) and North East India (Seitz, 1933; Chowdhury, 1981; Bhattacharya *et al.*, 2004; Singh and Suryanarayana, 2005). Preliminary investigation in Nagaland, India has ascertained that the worm is polyphagous in nature and feeds on six host plants, namely *Rhus javanica*, *Alnus nepalensis*, *Evodia flaxinifolia*, *Persea bombycina*, *Betula alnoides* and *Prunus cerasoides*, out of which the first two host plants are most preferred. These known host plants are different from the previous findings of Cotes (1891–1893). Potter (1941) reported *Heptapleurum octophylum* B & H (Anacardiaceae) as a host plant in Hongkong. Barlow (1982) reported seven species of host plants of *A. selene* from Northern India. Nassig and Peigler (1984) stated that Anacardiaceae was well known to be used by *Actias* as a host plant. Rajadurai and Thangavelu (2000) reported three species of host plants and carried out a detailed study on the biology of *A. selene* and put emphasis on its conservation for commercial utilization from Bhandra forest, Maharashtra, India. However, no information is available on the life history of this sericigenous insect in relation to its host plants from this region. Hence, a detailed study was undertaken on the biology and rearing performance of *A. selene* on the newly reported two primary host plants i.e. *Rhus javanica* and *Alnus nepalensis* at Govt. Sericulture Farm, Ungma, Mokokchung, Nagaland.

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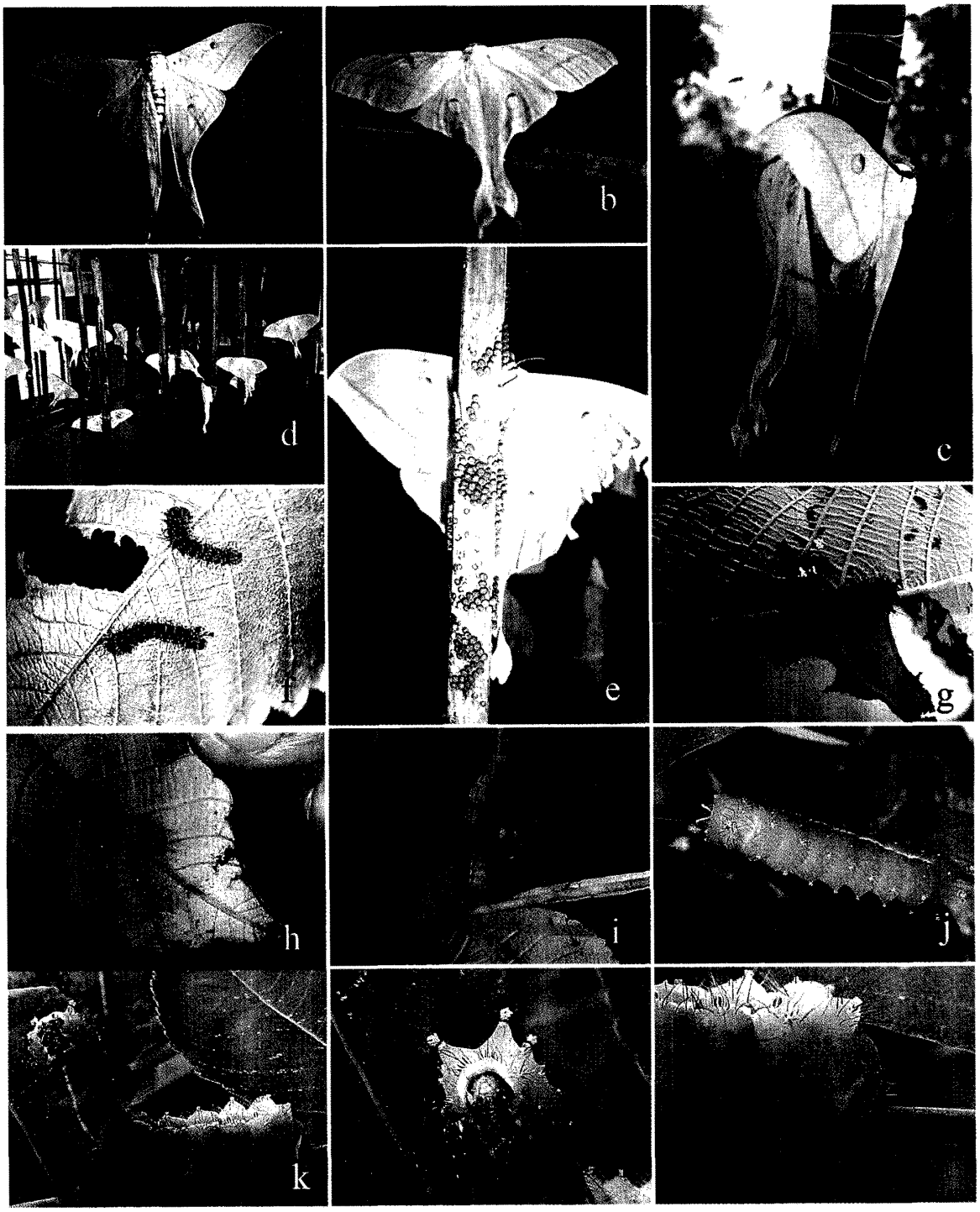

Fig.1. Life cycle of *Actias selene* Hübner.
a. Male, b. Female, c. Male-female pair, d. Mass grainage, e. Eggs, f. 1st instar, g. 2nd instar, h. 3rd instar after moult, i. 3rd instar, j. 4th instar, k. 5th instar, l. Mouth and tubercles (close up), m. Anal flap and claspers (close up).

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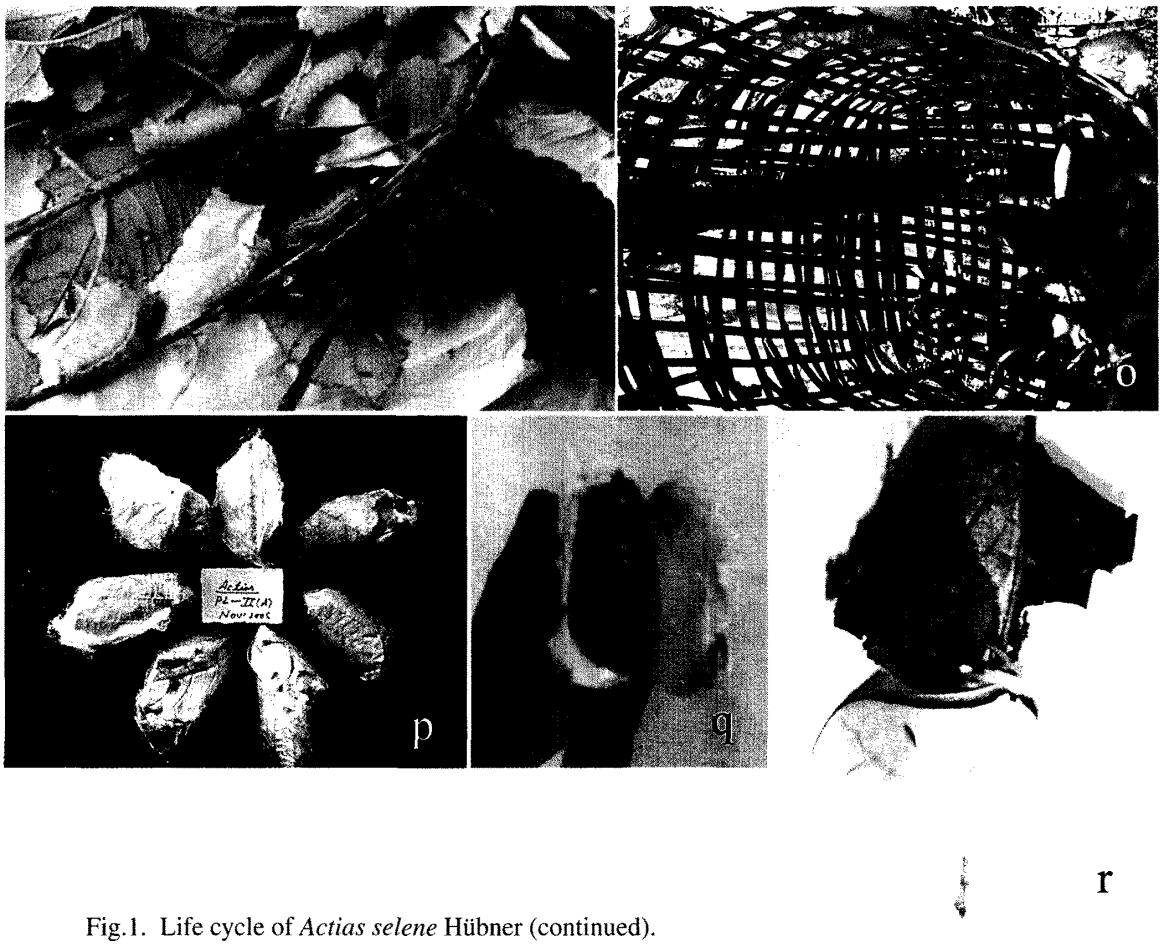

Fig.1. Life cycle of *Actias selene* Hübner (continued).
n. Mass rearing, o. Mature worms on mountage, p. Cocoons, q. Pupa, r. Moth eclosion.

Methods

Male and female (fertile) moths were collected from Sangtemla Ward, Alempang ward, Mokokchung Village and Ungma village areas of Mokokchung district from *Rhus javanica* and *Alnus nepalensis* host plants in 2005 and kept in wooden moth coupling cages for pairing. The cultural operation was conducted at the Muga seed grainage centre, Govt. sericulture farm, Ungma, Mokokchung. Female moths laid eggs on the floor and walls of the cage, which were collected and kept in an egg box at a room temperature of 19–21°C and relative humidity (RH) of 68–78%. Equal numbers of newly hatched larvae were released on the selected bush plantation of *Rhus javanica* and *Alnus nepalensis* (in triplicate) which were covered with nylon nets to protect the silkworms from predators and other enemies. However, worms which crawled down to the base of the tree after exhausting the leaves were transferred to new host plants. On maturity, the larvae were hand picked and kept in mountage for spinning of cocoons which were harvested after 8–10 days of pupation. The rearing and grainage experiment was conducted with strict observation for six consecutive generations during 2005–2006. Data were recorded for study of the biology which included parameters such as morphometric characters (length, breadth and weight), incubation period, larval duration, adult longevity and fecundity, taking ten replicates for each treatment. Abiotic factors were also recorded during the study period. The mean and standard error (SE) were calculated from the computed values. Randomized block design and completely randomized block design were used to analyse the field and laboratory data respectively (Gomez and Gomez,1978). Further, critical differences were calculated by using the F-test as described by Snedechor and Cochran

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Table 1. Measurement of developmental stages of *Actias selene* Hübner on two different host plants.

Parameters	HOST PLANTS[1)]	STAGES								
		Egg	1st	2nd	3rd	4th	5th	PUPA		ADULT	
								Male	Female	Male	Female
Length (cm) (Mean±SE)	A	0.25±0.003	0.84±0.10	1.56±0.19	2.90±0.20	4.94±0.20	8.66±0.63	3.70±0.06	4.42±0.10	2.90±0.18	3.84±0.25
	B		0.88±0.11	1.56±0.15	2.46±0.31	4.58±0.35	8.04±0.85	3.62±0.04	4.46±0.15	3.02±0.16	3.94±0.12
	S. Ed ±	0.002	0.13	0.23	0.32	0.22	0.26	0.07	0.12	0.2	0.15
	CD-5%	–	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	0.55*	*NS*
Breadth (cm) (Mean±SE)	A	0.23±0.005	0.16±0.02	0.26±0.05	0.58±0.08	0.84±0.09	1.40±0.07	1.34±0.05	1.46±0.11	1.34±0.21	1.46±0.05
	B		0.15±0.02	0.26±0.04	0.33±0.04	0.74±0.10	1.42±0.19	1.26±0.07	1.50±0.05	1.40±0.07	1.50±0.09
	S. Ed ±	0.004	0.02	0.07	0.07	0.11	0.12	0.07	0.09	0.18	0.08
	CD-5%	–	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Weight (gm) (Mean±SE)	A	0.004 ± 0.0003	0.03±0.01	0.58±0.04	1.08±0.26	3.26±0.35	11.73±1.41	4.64±0.07	7.35±0.29	3.60±0.44	4.94±0.24
	B		0.04±0.01	0.10±0.09	0.85±0.20	2.57±0.53	11.55±3.08	4.74±0.14	7.86±0.49	4.36±0.20	5.38±0.23
	S. Ed ±	0.000	0.01	0.08	0.24	0.31	1.82	0.19	0.73	0.41	0.17
	CD-5%	–	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

S. Ed ±: Standard error of standard deviation

CD: Critical difference

*: Significant at the 5% level of probability, NS: Not significant.

[1)] A: *Rhus javanica* (Tangmo), B: *Alnus nepalensis* (Alder).

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(1979). The measurement and assessment of commercial characters of cocoons were carried out by conventional methods.

Results and discussion

Life cycle parameters

The following descriptions were made from live specimens reared during 2005–2006 in the two newly reported food plants (Fig. 1a–r). The first instars were described within 2 days after eclosion, while all other instars were described within 2–3 days following a molt.

Egg (Fig. 1e). The oval dorso-ventrally compressed egg has a hard chitinised shell. Egg is about 2.5 mm in length and 2.3 mm in breadth, weighing about 0.004 gm. The colour of eggs is grey. Eggs are laid scattered and are covered wity gummy substances, due to which they get stuck to each other. Hatching takes place from morning to noon.

Each larval instar of the *A. selene* worm has a distinct body colour and tubercular arrangement.

First instar (Fig. 1f). The colour of the 1st instar larva of *A. selene* is chocolate (initially) and orange brown later on with one black band on the intersegmental region. Tubercles are black in colour and covered with black hair like setae.

Second instar (Fig. 1g). The colour is initially (just after moult out) chocolate and orange brown later on, the black band disappearing. Tubercles are black in colour and covered with black hairlike setae. Dorsal tubercles on T2 (2nd) and T3 (3rd) segments are bigger in size as compared to those on other abdominal segments. A8 (11th) segment possesses a single dorsal tubercle. Lower lateral tubercles and upper lateral tubercles appear on the T1–T3 and T2–A9 segments respectively. One pair of black spots appears between dorsal tubercles from A1 to A7 segments with spiracles both sides. In this stage the mouth is reddish brown in colour.

Third instar (Fig. 1h–i). After the 2nd moult, the body colour is initially yellowish green which changes to green later. Tubercles on 2nd and 3rd abdominal segments become yellow in colour surrounded by black stripe and are covered with black hairlike setae (8 to 9 nos.). However dorsal tubercles on T1 and A8 segment are without black stripe. The other tubercles of the larva are orange in colour.

Fourth instar (Fig. 1j). The body colour is bright green and tubercular arrangement and coloration is same as in the 3rd instar larva. In A9 and A10 the tubercles are bluish in colour. Lateral line and 9 pairs of spiracles are distinct at this stage. Mouth, anal flap and claspers are reddish brown in colour.

Fifth instar (Fig. 1k–m). The body becomes dark green in colour. Lower lateral tubercles appear distinctly on T1 to T3 segments and arrangement and coloration of the tubercles is the same as in the 4th instar larva. Thoracic legs are conical in shape and carry sharp digital claws. The pairs of abdominal legs on A3 to A6 segments become fleshy and flat at the end. At the time of maturation, the dark green colour of the larva turns to yellowish green.

The results presented in Table 1 emphasize the morphometry (length, breadth and weight) of *A. selene* in relation to the host plants. There were no significant variations in morphometric characters of the moon moth between the two host plants; however, significant differences in the average length of adult (Male) was recorded as 2.90±0.18 cm and 3.02±0.16 cm on *Rhus javanica* and *Alnus nepalensis* respectively. This might be due to difference in leaf quality of the food plants.

Pupa and cocoon (Fig. 1p-q). The matured larva builds its cocoon on fresh and dry leaves. It

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Table 2. Meteorological data in different rearing seasons during 2005–2006.

Parameters		2005			2006		
		Spring (Apr.–Jun.)	Summer (Jul.–Aug.)	Autumn (Oct.–Dec.)	Spring (Apr.–Jun.)	Summer (Jul.–Aug.)	Autumn (Oct.–Dec.)
Temperature (°C) (Mean±SE)	Max	30.67±1.53	31.67±3.21	27.0±6.0	32.0±1.0	32.67±0.58	26.0±5.0
	Min	17.0±3.0	20.67±2.08	10.0±2.65	16.67±3.51	19.33±0.58	10.0±3.46
Avg. Humidity(%) (Mean±SE)	Max	91.33±1.15	91.33±2.52	87.67±2.52	88.33±1.15	89.0±3.61	88.0±1.0
	Min	59.33±9.71	66±5.0	50.33±5.03	43.3±12.01	57.33±6.81	49.33±6.03
Rainfall/Day (mm) (Mean±SE)		7.36±1.92	10.01±4.72	1.89±2.93	8.54±2.87	11.82±5.81	0.52±0.55
Rainy Days (Nos.) / Month (Mean±SE)		9.33±4.93	21.33±3.79	6.33±7.57	17.0±8.0	22.0±5.20	2.33±2.31

spins its silk fibre around its body with the help of spinneret and tubercles. The pupa is dark brown in colour. The colour of the cocoon is pale cream to mushroom. Cocoons are soft with pale cream to mushroom colour. *Rhus javanica* and *Alnus nepalensis* are the most preferred host plants in Nagaland. *Rhus javanica* fed cocoons are grayish-brown to mushroom, whereas *Alnus nepalensis* fed cocoons are dull white to pale cream in colour. Earlier, Deodikar *et al.* (1969), Mohanraj *et al.* (1996), Rajadurai and Thangavelu (2000) reported such colour and quality of cocoons of this insect from other parts of India.

Adult (Fig. 1a–c, r). The wing span of the female moon moth is 135 to 157 mm, in the case of the male it is 102 to 129 mm. The moths are blue green with reduced chocolate and cream coloured eye spots. Costal line is of similar colour. Emergence of the moth takes place in the late morning to noon through the valve of the base of the cocoon. Just after emergence, it clings to the wall of the moth cage and remains there for 4–5 hours till its wings are fully stretched. Mating occurs on the same day (mid night), lasts only a short period of time and usually, eggs are laid the same evening. They do not prefer captive coupling. The male moth dies after 4–5 days of copulation and the female dies after 8–10 days of egg laying.

Seasonality and Effect of Host plants on rearing performance

Biology and rearing performance of *A. selene* (Fig. 1n-o) on two different host plants exhibited strong seasonality on growth and development in different stages. March-May (spring or commencing onset of monsoon), with average minimum and maximum temperatures of 16.67±3.51°C and 30.67±1.53°C respectively was the earliest breeding season for this insect. The relative humidity ranges from 57.33±6.81 to 91.33±1.15%. Second and third breeding periods correspond to summer (July-August) and autumn (October-December) seasons respectively (Table 2). The incubation period (days) was significantly shorter on both the host plants (13.5±0.17 days) during the second season, i. e. summer (July-August) and was longer on *Alnus nepalensis* (16.1±0.18 days) during the third rearing season. However, significant variations of incubation period within host plants i.e. *Rhus javanica* (14.40±0.16, 13.5±0.18 and 15.80±0.25) and *Alnus nepalensis* (14.60±0.16, 13.50±0.18 and 16.1±0.18) were recorded in different seasons respectively. Similarly total larval duration (days) was significantly shorter on *Alnus nepalensis* (30.6±0.73, 28.3±0.66 and 52.7±1.61 days) in comparison to *Rhus javanica* (33.3±0.72, 29.6±0.65 and 53.1±0.99 days) in the first, second and third rearing seasons respectively. The larval duration was found to be shorter during the 2nd season (summer) followed by the 1st season (spring) and 3rd season (autumn). This was due to changes of climatic conditions particularly temperature and relative humidity which increased from spring to summer and thereafter decreased towards autumn. The pupal period was found to be shorter on *Alnus nepalensis* (25.3±0.15 and 25.6±0.16 days) than *Rhus javanica* (27.1±0.28 and 25.8±0.20 days) during the 1st and 2nd rearing seasons respectively, while the pupa hi-

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Table 3. Seasonality and impact of host plants on life cycle parameters of *Actias selene* Hübner on two different host plants.

Seasons	Host Plants[1)]	Stages (Mean±SE)								
		Eggs	1st	2nd	3rd	4th	5th	Pupa	Adults	
									Male	Female
Season I	A	14.4±0.16	5.5±0.17	5.1±0.10	6.0±0.15	6.7±0.15	10.0±0.15	27.1±0.28	4.7±0.15	9.0±0.26
(Apr.-Jun.)	B	14.6±0.16	5.2±0.13	4.7±0.15	5.7±0.15	6.7±0.15	8.3±0.15	25.3±0.15	5.0±0.15	9.8±0.20
Season II	A	13.5±0.17	5.0±0.15	4.9±0.10	5.3±0.15	6.1±0.10	8.3±0.15	25.8±0.20	4.3±0.15	8.4±0.16
(Jul.-Sep.)	B	13.5±0.17	4.8±0.20	4.6±0.16	4.9±0.10	5.9±0.10	8.1±0.10	25.6±0.16	4.7±0.15	9.0±0.15
Season III	A	15.8±0.25	7.0±0.15	9.0±0.15	8.5±0.17	11.7±0.34	16.9±0.18	Diapause	4.4±0.16	7.9±0.10
(Oct.-Dec.)	B	16.1±0.18	6.9±0.10	8.7±0.15	8.5±0.17	10.8±0.25	17.8±0.94		4.5±0.17	8.4±0.16
Mean±SE	A	14.58±0.21	5.83±0.18	6.33±0.38	6.60±0.27	8.17±0.48	11.73±0.70	17.63±2.32	4.47±0.09	8.43±0.13
	B	14.73±0.22	5.63±0.19	6.00±0.37	6.37±0.30	7.80±0.41	11.40±0.90	16.97±2.23	4.73±0.10	9.07±0.14
S. Ed ±	Host Plant	0.18	0.14	0.14	0.15	0.18	0.41	0.17	0.16	0.18
	Season	0.18	0.14	0.14	0.15	0.18	0.41	0.17	0.16	0.18
	H x S	0.26	0.2	0.2	0.21	0.25	0.57	0.24	0.23	0.25
CD-5%	Host Plant	*NS*	*NS*	0.29**	*NS*	0.36*	*NS*	0.34***	*NS*	0.36***
	Season	0.37***	0.28***	0.29***	0.29***	0.36***	0.82***	0.34***	0.33*	0.36***
	H x S	*NS*	*NS*	*NS*	*NS*	0.51*	1.16**	0.49***	*NS*	*NS*

Total Larval Duration (Days)	Host plants	
	A	B
Season-I (April-June)	33.3±0.72	30.6±0.73
Season-II (July-August)	29.6±0.65	28.3±0.66
Season-III (October-December)	53.1±0.99	52.7±1.61

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, *NS*: Not significant.

[1)] A: *Rhus javanica* (Tangmo), B : *Alnus nepalensis* (Alder).

bernated for 97.6±4.37 days from winter to next spring due to the prolonged winter months in Nagaland (Table 3). The maximum adult longevity was recorded as 5.0±0.15 and 9.8±0.20 days in male and female respectively on *Alnus nepalensis* during the 1st rearing season whereas, the minimum was recorded as 4.3±0.15 and 7.9±0.10 days in male and female respectively on *Rhus javanica* during the 1st and 3rd rearing season.

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Effect on production parameters

The minimum and maximum fecundity (nos) was recorded during the second (211.40±12.66) and third (262.70±10.65) seasons while rearing on *Rhus javanica*, indicating the effect of seasonal variation (Table 4). Similarly, the highest percentage of hatching and effective rate of rearing (ERR) were recorded as 71.52±0.71 and 48.65±2.01 on *Rhus javanica* during the first and third rearing seasons respectively, while the lowest was recorded as 59.76±1.70 and 23.10±0.61 respectively on *Alnus nepalensis* during the second season. Cocoons per disease free laying (dfl) was maximum and minimum during the third (90.00±4.83) and second (30.70±1.86) seasons respectively on *Rhus javanica*. The important production parameters, i.e. fecundity (nos), hatching percentage, effective rate of rearing (ERR) and cocoon/dfl were significantly higher when larvae were fed on *Rhus javanica* than on *Alnus nepalensis*. Hence, the present investigation indicated that the 1st (April-June) and 3rd (October-December) seasons were more suitable for rearing of *Actias selene* and rearing performance on *Rhus javanica* was better than *Alnus nepalensis*, highlighting the effect of host plants on production parameters among the seasons.

There was no significant difference in cocoon parameters between the two host plants except for green cocoon weight of female and shell weight and shell ratio in both male and female (at 5% level). The 3rd rearing season recorded maximum shell weight both in male (0.34±0.02 gm in both food plants) and female (0.58±0.01 gm in *Alnus nepalensis*) cocoons. Maximum shell ratio (%) was also observed during the 3rd rearing season in male (6.99±0.25) and female (7.32±0.29) respectively on *Rhus javanica*. Further, the interaction effect due to host plant x season was non-significant except for significant differences in green cocoon length, weight and shell ratio (%) of the female (Table 5). Thus quality of both male and female cocoons in different seasons was significant in terms of commercial importance. The commercial value of *Actias selene* cocoons has been established by Watson (1911) and Rajadurai and Thangavelu (2000). However, Deodikar *et al.* (1969) and Mohanraj *et al.* (1996) contradicted that the papery cocoons of *Actias* were of little or no value sericulturally. This may be due to differences in utilization of food plantations because papery and flimsy types of cocoons are obtained from secondary food plants of inferior quality. Ananthakrishnan (1990) rightly pointed out that it is the host plant which plays a critical role in the determination of insect numbers and whole life history strategies. Similarly, silk yarn characteristics of *Actias selene* also did not show any significant variation between the two food plants in three different rearing seasons (Table 6). The yarn was golden yellow to creamy white depending on the host plants used for rearing. The yarn was coarser in texture. While the annual mean of all parameters i.e. filament length, denier and raw silk recovery of cocoons reared on *Rhus javanica* were found to be higher than from those on *Alnus nepalensis*, there was seasonal variatio between the two host plants. Filament length was recorded to be maximum on *Rhus javanica* (198.82±9.03 m) during the 3rd season (October-December), but it was maximum on *Alnus nepalensis* (163.22±8.56 m) in the 1st season (April-June). Similarly, maximum denier was found on *Rhus javanica* (11.57) and *Alnus nepalensis* (7.61) during the 2nd season (July-August) and 1st season (April–July) respectively. However raw silk recovery was higher on *Rhus javanica* than on *Alnus nepalensis* in all seasons. The maximum was recorded on *Rhus javanica* (58.86%) in the 1st season and the minimum on *Alnus nepalensis* (35.63) in the 3rd season (October-December). The cocoons of *A. selene* were easy to degum in 5–10 minutes and it was easy to de-floss individually to reel in single continuous filament. The filament length obtained from the single cocoon was comparatively lower. The lesser yield of reeled yarn might give an option to produce hand spun yarn which would be more economical and useful.

Slanky and Scriber (1985) showed that the quality of food consumed by larvae influenced the fecundity, growth rate, development time and survival of adults. Anathakrishnan (1990)

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Table 4. Seasonal variation of production parameters of *Actias selene* Hübner on two different host plants.

Seasons	Host Plants[1)]	Parameters (Mean±SE)			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoon/Dfls
Season I	A	227.30±13.86	71.52±0.71	45.19±1.84	74.40±6.86
(Apr-Jun.)	B	244.10±15.47	69.14±0.75	46.75±1.13	79.40±4.88
Season II	A	211.10±12.66	60.82±1.98	24.66±0.72	30.70±1.86
(July-Sept)	B	231.20±10.95	59.76±1.70	23.10±0.61	31.80±1.74
Season III	A	262.70±10.65	69.54±1.22	48.65±2.01	90.00±4.83
(Oct.–Dec.)	B	252.90±13.28	71.03±1.34	46.34±1.83	85.20±5.74
April–December	A	233.70±8.01	67.29±1.17	39.50±2.17	65.03±5.42
	B	242.73±7.63	66.64±1.18	38.73±2.18	65.48±5.09
S. Ed ±	Host plant	12.66	1.35	1.55	4.62
	Season	10.34	1.35	1.55	4.62
	Host plant × Season	17.9	1.91	2.19	6.54
CD-5%	Host plant	*NS*	*NS*	*NS*	*NS*
	Season	20.84*	2.73***	3.12***	9.32***
	Host plant × Season	*NS*	*NS*	*NS*	*NS*

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, *NS*: Not significant.
1) A : *Rhus javanica* (Tangmo), B : *Alnus nepalensis* (Alder).

rightly pointed out that it was the host plant which plays the critical role in the determination of insect numbers and whole life history strategies. Evaluations of suitable food plants in relation to growth, development and reproductive potential of other silkworm species such as *Bombyx mori* Linn. (Saratchandra *et al.*, 1992), *Antheraea assamensis* Helfer (Chaudhury et al., 2000), *Antheraea mylitta* Drury (Rath, 2000), *Samia ricini* Donovan (Jayaramaiah and Sannapa, 2000) have also been made earlier. Mulken and Brusven (1962) and Mc Caffery (1975) pointed out that egg production in insects was influenced by host plant selection. The qualitative and quantitative characters of the cocoon greatly varied and much depended upon the type of food plants used (Sharma *et al.*, 1995). Krishnaswamy *et al.* (1971) also observed that growth, development, and the economic characters of the cocoons were greatly influenced by the nutritional content of mulberry leaves. Cotes (1891–93) reported that *Actias selene* passed through two generations in summer in Sikkim, while Rajadurai and Thangavelu (2000) observed trivoltinism of this species in Bhandara forest in Maharashtra. Mohanraj *et al.* (1996) emphasized that *Actias callandra*, an endemic species of the Andaman Islands, bred during most months and went through a period of diapause as a pupa coinciding with the period of leaf shedding of its deciduous host plant *Lannea coromandelica* Houtt. Rajadurai and Thangavelu (2000) while studying the biology of *Actias selene* on three different host plants observed a strong influence of host plants on colour and morphometry of immature stages and adults, life cycle parameters, larval duration, reproductive programming and commercial characters of cocoons.

A. selene, Hübner, was found to be completely free from other silk worm diseases like pebrine, muscardine but a minor infestation of flacherie was noticed in the month of July-August which may be due to maximum temperature, heavy rainfall and maximum moisture content of the host plant leaves. Infestation of uzi fly and enemies like ants, wasp and predatory birds were observed to a certain extent. *Rhus javanica* is an important traditionally used medicinal plant in Nagaland and *Alnus nepalensis* is also predominantly used for furniture and fire wood. Both

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Table 5. Seasonal variation of cocoon parameters of *Actias selene* Hübner on two different host plants.

Seasons	Host Plant[1)]	Parameters (Mean±SE)									
		Green Cocoon (Male)			Green Cocoon (Female)			Shell Wt. (gm)		Shell ratio (%)	
		L (cm)	B (cm)	Wt. (gm)	L (cm)	B (cm)	Wt. (gm)	Male	Female	Male	Female
Season I	A	4.74±0.06	1.91±0.05	5.03±0.15	5.68±0.09	2.33±0.07	8.36±0.22	0.30±0.01	0.47±0.02	6.03±0.20	5.63±0.15
(Apr.-Jun.)	B	4.49±0.09	2.08±0.06	4.84±0.28	5.30±0.17	2.57±0.09	7.50±0.32	0.30±0.02	0.46±0.02	6.27±0.22	6.13±0.19
Season II	A	4.67±0.07	1.87±0.05	4.99±0.20	5.47±0.15	2.40±0.06	7.60±0.24	0.29±0.01	0.46±0.02	5.91±0.15	6.11±0.16
(Jul.-Aug.)	B	4.58±0.10	1.95±0.06	4.88±0.18	5.71±0.13	2.43±0.06	7.60±0.29	0.29±0.01	0.44±0.02	5.96±0.21	5.77±0.19
Season III	A	4.74±0.18	1.92±0.08	4.84±0.13	5.39±0.17	2.42±0.07	7.36±0.37	0.34±0.02	0.53±0.02	6.99±0.25	7.32±0.29
(Oct.-Dec.)	B	4.71±0.16	1.82±0.07	5.34±0.30	5.72±0.13	2.40±0.08	9.38±0.34	0.34±0.02	0.58±0.01	6.38±0.31	6.21±0.24
April-	A	4.72±0.06	1.90±0.04	4.96±0.09	5.51±0.08	2.38±0.04	7.77±0.08	0.31±0.009	0.49±0.01	6.31±0.15	6.35±0.18
December	B	4.59±0.07	1.95±0.04	5.02±0.15	5.58±0.09	2.47±0.05	8.16±0.24	0.31±0.01	0.49±0.02	6.20±0.14	6.04±0.12
S. Ed ±	Host Plant	0.12	0.06	0.22	0.13	0.07	0.27	0.01	0.02	0.23	0.21
	Season	0.12	0.06	0.22	0.13	0.07	0.27	0.01	0.02	0.23	0.21
	H x S	0.17	0.09	0.31	0.18	0.1	0.38	0.02	0.02	0.32	0.3
CD-5%	Host Plant	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
	Season	*NS*	*NS*	*NS*	*NS*	*NS*	0.54*	0.03**	0.03***	0.46**	0.43***
	H x S	*NS*	*NS*	*NS*	0.36*	*NS*	0.76***	*NS*	*NS*	*NS*	0.61**

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, *NS*: Not significant.

[1)] A: *Rhus javanica* (Tangmo), B: *Alnus nepalensis* (Alder).

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Table 6. Single cocoon characteristics of *Actias selene* Hübner.

Seasons	Host plants[1)]	Filament length (m) (Mean ± SE)	Filament denier (d)	Raw silk recovery (%)
Apr.-Jun.	A	152.8±19.36	7.16	58.86
	B	163.22±8.56	7.61	43.32
Jul.-Aug.	A	78.10±4.41	11.57	49.65
	B	86.84±5.40	8.85	37.82
Oct.-Dec.	A	198.82±9.03	5.09	41.57
	B	152.99±15.96	6.67	35.63
Mean± SE	A	143.24±10.93	7.94	50.03
	B	134.35±9.97	7.72	38.92

[1)] A: *Rhus javanica* B: *Alnus nepalensis*

the plants are abundantly available throughout the state and can be easily planted for rearing of *A. selene* along with other commercially exploited silkworm species. Due to less exploitation by local sericulture farmers as well as unawareness about the species, the present rich fauna of *A. selene* may face an extinction problem in the future. Thus, the critical evaluation of suitable conservation and utilization strategies is urgently required for the establishment of *A. selene* as a resourceful, disease resistant and genetically stable breeding material for maintaining a flourishing sericulture industry along with other silk moths.

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摘　要

オナガミズアオ (鱗翅目:ヤママユガ科) のインドナガランドにおける生態と飼育 (Chutia, B. C., Kakati, L. N.)

オナガミズアオ *Actias selene* は，アフガニスタン，インド，ボルネオ，中国，日本などに分布する．成虫は大型で美しく，マユから絹糸をとれることから，インド北部では，本種の保全と養蚕業としての商業的な利用が検討されている．予備調査では，インド東北部のナガランドでは野外条件で年3化，ヌルデ (*Rhus javanica*) とハンノキの一種 (*Alnus nepalensis*) を中心に6種の寄主植物を利用することが分かっていたが，寄主植物や季節の違いによる発育等の研究は行われていなかった．そこで，本研究では，2005–2006年に2年連続で，ナガランドにおいてもっとも選好性の高いと考えられるヌルデとハンノキの一種について3つの異なる季節，春期 (3–5月)，夏期 (7–8月)，秋期 (10–12月) に野外条件での飼育を行い，形態，増殖に関わる変数 (蔵卵数，孵化率，飼育効率 ERR，病気に感染していない1♀が産んだ卵あたりのマユ数 Cocoon/Dfl，幼虫期間，マユの色・形状等の比較を行った．

その結果，幼虫の体長や体重については，寄主植物の違いによる差はなかったが，マユの色はやや異なっていた．幼虫期間は，両方の寄主植物で夏期がもっとも短く，続いて春期，秋期の順となった．また，いずれの寄主植物で飼育した場合も，夏期に増殖に不適となり，春期や秋期にヌルデで飼育した場合の蔵卵数，孵化率，飼育効率などが最大値を示した．さらに，マユの殻率は，ヌルデで秋期に飼育したものがもっとも高かった．以上のことから，ナガランドにおいて商業的利用を目的としたオナガミズアオの増殖は，春期と秋期にヌルデを用いて行うのがよいことが示された．

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